



TITLE:

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Quantum chaos and semiclassical theory in molecular science and nuclear theory,
Chaos and Nonlinear Dynamics in Quantum-Mechanical and Macroscopic Systems)

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CITATION:

Odagiri, Kenta ...[et al]. Effects of spatiotemporal fluctuation of temperature on cluster formation(4) Quantum chaos and semiclassical theory in molecular science and nuclear theory, Chaos and Nonlinear Dynamics in Quantum-Mechanical and Macros ...

ISSUE DATE:

2005-06-20

URL:

<http://hdl.handle.net/2433/110207>

RIGHT:

Effects of spatiotemporal fluctuation of temperature on cluster formation

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従来のクラスター形成の研究の多くでは、時空間熱ゆらぎは考慮されていなかった。そこで、時空間熱ゆらぎの効果を取り入れたクラスター形成過程を Cellular Automata 上で再現した。本研究では、特に時空間熱ゆらぎの影響に着目した観察解析を行った。これにより、クラスター形成と時空間熱ゆらぎの関連性について幾つかの興味深い結果が得られた。

1 Introduction

In many studies of mesoscopic-scale dynamics, temperature is regarded as a macroscopic parameter with no spatiotemporal fluctuation. However, a nonlinear interaction between the relevant particles and local spatiotemporal fluctuation of surrounding physical quantities such as temperature must be vital. If so, what effects do spatiotemporal fluctuation of temperature in the atomic scale?

To consider these effects, we devise cellular automata (CA) for overdamped stochastic dynamics of particles (atoms). In this study, we watch and analyze effects of spatiotemporal fluctuation of temperature, with special attention.

2 Model

We study a stochastic dynamics of many identical particles (atoms) moving on a flat two-dimensional surface of a substrate. The particles move by the random impacts from the substrate. The particles combine with each other on aggregating, then a new chemical bond generates heat to the substrate. Conversely, bond-breaking and/or particle-moving consume heat from the substrate. With this scheme, we construct Coupled Cellular Automata (CCA). More details for model and CCA are described in our paper [1].

3 Results

To study effects of spatiotemporal fluctuation of temperature, we build two CA systems. One is a system of relatively fast heat diffusion, in which thermal field tends to be equilibrated quickly. The other is a system of very slow heat diffusion, in which heat emitted by clustering remain and are localized at the places where they were born.

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To characterize our cluster growth in the later stage, we examine the structure factor [1, 2] for each system. Fig. 1 shows it.

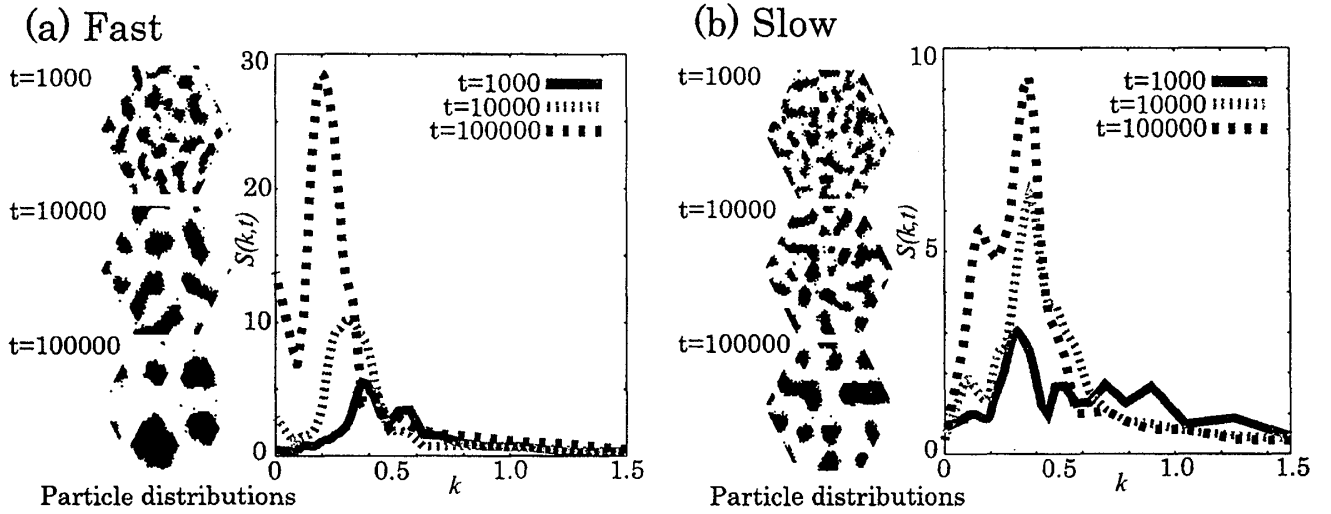


Fig. 1: Particle distributions and structure factors for the cluster growth in the later stage, (a) Fast heat diffusion system, (b) Slow heat diffusion system.

In the "Fast" system, the intensity of $S(k, t)$ at the highest peak becomes higher and shifts to the lower wave-number as time passes. It means that clusters grow larger and larger and the distances between the clusters become wider. This feature is quite well-known as a characteristic feature in the growth of spinodal decomposition [2].

In the "Slow" system, on the other hand, the highest peak becomes higher as time passes, but rarely shifts to the lower wave-number. It means that the clusters becomes large, but the spacings between the clusters don't becomes wider. In this system, slow heat diffusion prevents the clusters from moving.

Omitting on account of space, we further quantify and characterize the stability of clusters and their boundaries. Owing to this quantification, we find out some interesting phenomena [1].

And then, we now extend our CA which is composed of different particles (atoms). More extensive studies will be reported elsewhere.

References

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